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BREEDING ECOLOGY OF LONG-BILLED CURLEWS AT GREAT SALT LAKE, UTAH

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Abstract.—We quantified nest site characteristics, breeding densities, and migratory chronology of Long-billed Curlews at Great Salt Lake, Utah. The species is apparently declining in Utah, and little is know about their breeding ecology in the eastern Great Basin Desert. This study was designed to provide wildlife biologists with baseline data useful for their successful management. Curlews arrived in northern Utah in late March and generally departed by mid-August. Nest densities at Great Salt Lake ranged from 0.64 to 2.36 males/km^2. The habitat at curlew nest sites consisted of significantly shorter vegetation than nearby random locations ($\bar{x}$ = 5.7 versus 9.0 cm, respectively; $P < .01$). Nests tended to be located in small patches of vegetation near barren ground. Maintenance of relatively short vegetation appears to be important in managing curlew habitat. In addition, only 2 of 10 nests we monitored in 1992 were successful, with most lost to mammalian predators. Further research is needed to determine the impact of mammalian predators on curlew populations.

Key words: Long-billed Curlew, Numenius americanus, *nest site characteristics, migration chronology, Utah.*

Long-billed Curlews (*Numenius americanus*) historically were a common species in the grasslands of North America (Pampush 1980). Although quantitative population trend data are limited, it appears that habitat alterations and hunting dramatically reduced populations throughout their breeding range (Allen 1980, Pampush 1980). In Utah, Long-billed Curlews are presently being considered for listing as a sensitive species due to declining populations in the northern part of the state (Frank Howe, Utah Division of Wildlife Resources, Salt Lake City, personal communication). However, reasons for this decline are unknown. Therefore, wildlife managers in Utah require quantitative information on their breeding ecology in the eastern Great Basin Desert to successfully manage this species.

Two variables that wildlife biologists can manage to some extent are vegetation and predators. Previous studies in Idaho (Bicak et al. 1982, Redmond and Jenni 1986), Oregon (Pampush 1980), and Wyoming (Cochran and Anderson 1987) suggest that Long-billed Curlews select nest sites in grasslands with relatively short vegetation. Changes in vegetation height due to field fertilization, grazing, and precipitation can significantly affect curlew nest success (Bicak et al. 1982, Redmond and Jenni 1986, Cochran and Anderson 1987). In addition, predators can have a major impact on a curlew population because Long-billed Curlews initiate only one clutch per year and do not re-nest once a nest has been depredated (Redmond and Jenni 1986).

Little quantitative information has been published on the breeding ecology of Long-billed Curlews in Utah. Wolfe (1931) provided qualitative information on their habitat characteristics, and Forsythe (1972) described four nests found near Great Salt Lake. Our objective is to provide quantitative estimates of curlew migration chronology, current distribution and breeding densities, nest success, and nest site habitat characteristics at Great Salt Lake so that biologists managing this shorebird in northern Utah will have baseline information.

Study Area

Our principal study areas were three state-owned wildlife refuges located along the eastern shores of Great Salt Lake (Paton and Edwards 1990): Howard Slough Waterfowl Management Area (WMA), 311 ha surveyed (41°10′N,112°10′E); West Layton marsh, 339 ha (41°0′N,112°0′E), and West Warren WMA,

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400 ha (41°20′N,112°05′E). Satellite study sites included North Ogden Bay WMA, 500 ha (41°15′N,112°10′E); Harold Crane WMA, 1300 ha (41°20′N,112°05′E); Locomotive Springs WMA, 1000 ha (41°40′N,112°55′); and northeast of Saltair Beach, 600 ha, (40°45′N,112°10′E). All sites receive approximately 25–38 cm of precipitation annually (Greer 1981) and are located at an elevation of 1283–1289 m. Marsh vegetation in these areas is dominated by bulrush (*Scirpus* spp.) and cattail (*Typha* spp.). Upland habitats are dominated by greasewood (*Sacrobatus vermiculatus*) and several species of Chenopodiaceae (*Salicornia europaea*, *Bassia hyssopifolia*, *Kochia scoparia*, *Suaeda calceoliformis*).

METHODS

Fieldwork was conducted 14 April–11 August 1990, 27 March–19 September 1991, and 19 March–10 September 1992. To determine curlew migratory chronology, distribution, and breeding densities, we surveyed principal study areas one day per week 1 April–31 August, except 1990, using spot-mapping techniques (Redmond et al. 1981). Surveys were started at sunrise and continued for 3–5 hours per day. Curlews were censused using only spot-mapping techniques at West Warren in 1992. Satellite study sites were visited 1–3 times per month all 3 years, with curlews counted from road transects during shorebird surveys (Paton et al. 1992). Weekly census data at Howard Slough and West Layton from 1991 and 1992 were compared using a paired *t* test.

To determine their breeding chronology in Utah, we actively searched for curlew nests in 1992 following methods outlined in Redmond (1986). Egg-laying dates for active clutches were determined using egg-floating techniques (Hays and LeCroy 1971). Observations of juveniles in 1990 and 1991 were used to supplement chronology data gathered in 1992. Clutch initiation dates for juveniles observed in the field were calculated by estimating age of the chick and then back-dating based on a 28-day incubation period (Redmond and Jenni 1986) and 6-day egg-laying period (Cochran and Anderson 1987).

We determined curlew nest site characteristics based on nests found in 1992. Vegetation was quantified using a line-intercept technique (Hays et al. 1981:40). To minimize the probability of attracting predators to active nests, measurements were made <1 week after nests either hatched or failed. Nest site habitat characteristics were quantified along four 15-m transects initiated at the rim of each nest scrape, with transects arranged in the four cardinal directions. To quantify the curlew habitat patch use patterns versus the available landscape, each nest had a paired set of transects, centered on a point located 50 m in a random direction (hereafter referred to as random sites). Random sites were located only in areas with potentially suitable habitat (i.e., dry, upland vegetation <15 cm tall; Pampush 1980, Redmond and Jenni 1986, Cochran and Anderson 1987). Vegetation height was measured at 0.5-m increments along the transect, starting at the nest rim (that is, 31 points per transect). The height of the tallest plant within 5 cm of the transect was measured. Plant species composition at nests and random sites was determined by measuring to the nearest 1 cm each plant species that touched the transect tape. For vegetation coverage analyses, we classified each 1-cm segment along transects as either live vegetation, dead vegetation, or barren ground.

We compared vegetation height at nests and the paired random sites with a paired *t* test to quantify vegetational differences between used and available patches. To quantify variation in vegetation height as a function of the distance from plot center, at both nests and random sites, we categorized the data into five 3-m-long distance segments. These distance segments were then compared using analysis of variance (ANOVA) and Duncan's Multiple Range Test to determine which segments differed using PROC ANOVA in SAS (SAS Institute 1988). Alpha values <.05 were considered statistically significant.

We compared ground coverage between nests and random sites using a paired *t* test for three vegetation categories (live, dead, and barren ground). To determine if the three vegetation categories differed as a function of the distance from plot center, we again classified the data into five 3-m-long segments. The distance segments were then compared using ANOVA and Duncan's test, at both nests and random sites.

TABLE 1. Maximum number of Long-Billed Curlews counted during weekly censuses at two study sites at Great Salt Lake.

	Howard Slough WMA			W. Layton WMA		
Date	1990	1991	1992	1990	1991	1992
Apr 1–7	NC[a]	5	4	NC	1	1
Apr 8–15	NC	13	6	NC	12	4
Apr 16–22	NC	8	10	NC	5	4
Apr 23–30	NC	12	7	NC	4	10
May 1–7	NC	9	14	NC	3	15
May 8–15	NC	6	12	NC	4	23
May 16–22	NC	5	14	NC	6	15
May 23–31	NC	9	11	NC	3	15
Jun 1–7	4	5	11	NC	5	14
Jun 8–15	0	3	4	2	5	9
Jun 16–22	1	0	2	2	3	3
Jun 23–30	0	1	6	3	6	3
Jul 1–7	0	2	3	3	9	5
Jul 8–15	1	1	10	1	2	10
Jul 16–22	0	0	10	3	5	8
Jul 23–31	0	0	20	1	8	5
Aug 1–7	0	0	0	0	4	8
Aug 8–15	0	0	1	0	1	3
Aug 16–22	0	0	0	0	0	0
Aug 23–31	1	0	0	0	0	0

[a]No census data

RESULTS

MIGRATION AND NESTING CHRONOLOGY.— Our weekly surveys were generally initiated 1 week after Long-billed Curlews started to arrive in Utah. Cursory surveys from mid- to late March and observations by Forsythe (1970) indicated that Long-billed Curlews arrive in Utah during the last week of March (Paton et al. 1992; Table 1). No curlews were observed at Howard Slough on 27 and 30 March 1991, while one bird was seen on 31 March. In 1992 no curlews were seen on visits to Howard Slough or West Layton on 19 March and Harold Crane on 26 March, whereas three birds were seen on 30 March at Howard Slough and two curlews were at West Layton on 31 March.

By mid-April most curlews that nested around Great Salt Lake appeared to have arrived and established territories. However, not all curlews seen during April were local breeding birds, as flocks of 2–20 birds were often seen flying north over the study sites during the second and third weeks of April. For example, a flock of 11 birds was migrating north on 11 April 1991 over Howard Slough. On 14 April, 20 curlews were foraging near Brigham City in a pasture not used by resident curlews. By the end of April all three years, flocks that appeared to be migrating curlews were no longer observed.

Long-billed Curlew nests were initiated from mid-April to mid-May in northern Utah, based on floating eggs and observations of juveniles. Analysis of egg-floating data from 1992 showed that four clutches were initiated in late April, three the first week of May, and three the second week of May. In addition, juveniles 3–4 days old were found on 23 May 1990 and 2 June 1990 at Locomotive Springs, and five broods (all >1 week old) were seen on the east side of Antelope Island on 23 May 1992. Based on back-dating, their nests were all started about the third to fourth week of April.

Fall migration was relatively early for most curlews at Great Salt Lake compared with other shorebirds (Paton et al. 1992). The number of curlews seen on our two principal study sites declined dramatically after the first week of June. We saw no obvious evidence to suggest that Long-billed Curlews attempted to re-nest after nests were depredated. In fact, most adults remained on territory for only 2–3 weeks after nests were depredated and then vacated the study areas.

There was an influx of birds at West Layton and Howard Slough from mid-July to late July (Table 1). These flocks were probably migrants, either from other areas around Great Salt Lake or possibly farther north. These flocks often had one or two adults (both sexes) and 2–4 juveniles, suggesting the possibility they were sometimes migrating family groups, although this has not been previously reported. The largest late-summer migratory flock we observed during 3 years of fieldwork was 38 birds on 25 July 1990 at Salt Well Flats, located at the northwestern corner of Promontory Point. It was extremely rare to see any curlews during surveys at our study areas after 15 August (Table 1). Our latest Utah record was one bird on 27 August at Layton.

DENSITY ESTIMATES.—In 1990, surveys were initiated too late to estimate the number of breeding adults at the principal study areas. Survey data from the two principal study areas suggested more curlews were sighted in 1992 than in 1991 (Howard Slough: $t = -2.51$, df = 19, $P < .02$; Layton: $t = -2.4$, df = 19, $P < .03$; Table 1). Howard Slough had 2 nesting pairs of curlew in 1991 (0.64 pairs/km^2) and 6 pairs in 1992 (1.92 pairs/km^2), while West Layton had 2 nesting pairs in 1991 (0.59 pairs/ km^2) and 8 pairs in 1992 (2.36 pairs/km^2). At West Warren, we estimated 9 breeding pairs in 1992 (2.25 pairs/km^2). Although the data are limited, nearest-neighbor nest distances averaged 480.4 m (range = 351–1158 m, $n = 6$).

Surveys at satellite study areas found no evidence to suggest that Long-billed Curlews nested at Harold Crane or north of Saltair during any year of the study. No curlews nested at North Ogden Bay in either 1990 or 1991, and 1–2 pairs nested there in 1992. Locomotive Springs was surveyed most thoroughly in 1990, when we estimated a minimum of 6 pairs nesting in the area. One of the largest nesting concentrations of curlews we observed at Great Salt Lake was in late May 1992 on the east side of Antelope Island, where at least 8 pairs were seen along 2 km of road approximately 1.5 km northwest of Seagull Point. Interestingly, other ground-nesting species (Short-eared Owls [*Asio flammeus*] and Northern Harriers [*Circus cyaneus*]) were also relatively common on the east side of Antelope Island, compared to other areas at Great Salt Lake (P. Paton personal observation).

CLUTCH SIZE AND NEST SUCCESS.—All nests in which we were able to determine final clutch size had four eggs ($n = 9$). Only 2 of the 10 nests we found in 1992 were successful. Seven nests were depredated by mammalian predators. Red fox (*Vulpes vulpes*) was the primary nest predator for Snowy Plovers on the east side of the lake (Paton and Edwards 1990) and probably depredated most curlew nests. In addition, one nest at Layton was possibly depredated by another curlew, based on the diameter of puncture holes found in the egg shells (Redmond and Jenni 1986). We were unable to determine fledging success.

NEST SITE CHARACTERISTICS.—Ten Long-billed Curlew nests were found in 1992. Curlews appeared to select nest sites in habitats with relatively short vegetation, often near barren patches of ground. Vegetation within 15 m of nest sites was significantly shorter than vegetation at random sites (paired $t = -10.7$, df = 1239, $P < .0001$; Table 2). Vegetation near nest sites (<6 m) was significantly taller than that far (≥ 6) from nests (Table 2). In contrast, there was no significant variation in vegetation height at random sites as a function of distance from plot center (Table 2).

Curlews selected nest sites in small clumps of live/dead vegetation, and near the nest there was relatively little barren ground (Table 3). In fact, the amount of barren ground near nest sites was the only vegetation variable that showed any significant variation as a function of distance from plot center (Table 3). Therefore, it appears that Long-billed Curlews did not select habitat patches based on the

TABLE 2. Mean (±SE) vegetation height (cm) of Long-Billed Curlew nest and random sites at Great Salt Lake, Utah ($n = 10$). Means lacking similar letters are significantly different (ANOVA, $P < .05$, Duncan's Multiple Range Test).

	Distance from plot center (m)							
	0–2.9	3.0–5.9	6.0–8.9	9.0–11.9	12.0–15.0	0–15.0	*F*	*P*
Nest sites	6.5 ± 0.3A	6.0 ± 0.4AB	5.3 ± 0.3B	4.9 ± 0.4B	5.5 ± 0.5B	5.6 ± 0.2	2.98	.018
Random sites	8.1 ± 0.5A	9.5 ± 0.8A	9.3 ± 0.8A	9.8 ± 0.7A	8.6 ± 0.7A	9.0 ± 0.3	1.11	.35

TABLE 3. Mean (±SE) vegetation coverage of Long-Billed Curlew nest and random sites at Great Salt Lake, Utah. Means lacking similar letters are significantly different (ANOVA, $P < .05$, Duncan's Multiple Range Test).

	Distance from plot center (m)							
	0–2.9	3.0–5.9	6.0–8.9	9.0–11.9	12.0–15.0	0–15.0	F	P
Nest sites								
% live vegetation	56 ± 4.6A	45 ± 5.6A	43 ± 6.1A	40 ± 6.3A	46 ± 6.6A	46 ± 4.2	1.1	.357
% dead vegetation	26 ± 4.2A	27 ± 5.9A	19 ± 5.4A	21 ± 5.7A	15 ± 4.5A	22 ± 4.3	1.0	.418
% barren ground	18 ± 3.9A	28 ± 5.2AB	38 ± 6.3B	39 ± 6.7B	39 ± 6.7B	32 ± 4.9	2.6	.037
Random sites								
% live vegetation	39 ± 6.3A	37 ± 6.0A	32 ± 5.5A	28 ± 5.9A	36 ± 6.4A	34 ± 4.6	0.5	.735
% dead vegetation	28 ± 6.1A	28 ± 5.6A	33 ± 6.9A	36 ± 6.9A	30 ± 6.2A	31 ± 5.2	0.3	.894
% barren ground	33 ± 6.4A	35 ± 6.7A	35 ± 6.7A	36 ± 6.4A	34 ± 6.6A	35 ± 5.9	0.1	.997

proportions of dead and live vegetation available, but rather vegetation height seemed to be the key variable. There was a weak tendency for curlew nest sites to be located in areas with slightly more live vegetation than in random transects (t = 1.81, df = 18, P = .07), whereas nests and random sites did not differ in the amount of dead vegetation (t = −1.3, df = 18, P = .19) or barren ground (t = −0.3, df = 18, P = .74; Table 3).

The most common plant species, with common defined as averaging >3% total coverage, within 15 m of the 10 nests were *Salicornia europaea* ($\bar{x}$ = 13.2% live, 7.7% dead), *Bassia hyssopifolia* (14.7% live, 3.2% dead), *Suaeda calceoliformis* (11.5% live, 6.1% dead), *Distichlis spicata* (4.3% live), and *Chenopodium album* (0.3% live, 3.2% dead).

DISCUSSION

Nesting densities in northern Utah found during this study were intermediate relative to estimates for other regions of western North America. Sadler and Maher (1976) reported relatively low densities (0.14–0.17 pairs per km^2) at the northern limits of their range in Saskatchewan, which would be expected. Densities similar to those in our study were found in southeastern Washington (0.58–1.45 pairs per km^2; Allen 1980) and north central Oregon (up to 3.6 per km^2; Pampush 1980), which would be expected given that both sites were at latitudes similar to those in northern Utah. An area with consistently high densities is the shortgrass rangelands of western Idaho (6.4 males and 5.3 females per km^2; Redmond et al. 1981). The exact reasons for this variation in population densities across the species' range are unclear, yet should be studied further to assess factors regulating their populations. For example, little is known about prey and predator densities in various parts of the curlew range.

Other aspects of Long-billed Curlew breeding ecology at Great Salt Lake were similar to results reported from other parts of their range. Four eggs is the typical clutch size for the species (Pampush 1980, Redmond 1986). Somewhat surprisingly, the migratory chronology of Utah birds was different from that of southeastern Washington (Allen 1980), with birds in northern Utah arriving later and remaining longer. However, although southeastern Washington is farther north than Utah, it is also lower in elevation (ca. 225 m) and has a milder climate than Great Salt Lake, which probably explains why curlews arrive earlier in Washington. As with the migratory chronology, clutch initiation dates vary with climate. Clutches in northern Utah were started from mid-April to mid-May during our study, which was 2 weeks later than in western Idaho (Redmond 1986), southeastern Washington (Allen 1980), and north central Oregon (Pampush 1980). However, in central Wyoming, clutches were initiated 1–2 weeks later than at Great Salt Lake (Cochran and Anderson 1987).

Vegetation height seems to be one of the fundamental habitat characteristics used by Long-billed Curlews to select breeding areas. Curlews tend to nest in areas with vegetation <10 cm tall (Allen 1980, Pampush 1980, Bicak et al. 1982, Cochran and Anderson 1987, this study). Structural characteristics of their nesting habitat at Great Salt Lake are relatively similar to those in other regions of western North America, although specific plants were different. As in this study, Pampush

(1980) found that curlews in north central Oregon selected nest sites with generally lower vertical profile and lower vertical density than the surrounding habitat. Bicak et al. (1982) found a negative correlation between Long-billed Curlew abundance and vegetation height, with more birds using areas with short vegetation. Since curlews use areas with relatively short vegetation, Bicak et al. (1982) suggested that livestock grazing prior to the onset of the breeding season could increase use of an area by nesting curlews. Redmond (1986) reported that relatively tall vegetation (40 cm tall) affected their foraging activities, and that an increase in plant height in nesting habitat (>12 cm tall) due to the previous year's growth delayed egg laying the subsequent year. Therefore, all studies in western North America indicate that relatively short vegetation is among the key habitat variables that wildlife managers must be concerned with to maintain curlew nesting habitat.

Nesting Long-billed Curlews at Great Salt Lake seem to prefer areas that provide good visibility of the surrounding habitat during incubation. This conclusion was similar to habitat studies from other parts of its range (Allen 1980, Cochran and Anderson 1987). At Great Salt Lake the ground is relatively level and curlews prefer to nest near the edges of barren alkali flats. Wolfe (1931) also reported that curlews nested near barren areas at Great Salt Lake. Interestingly, Cochran and Anderson (1987) reported that Long-billed Curlews avoided fields with extensive barren ground, although they did not determine if curlews had a threshold value for barren ground. Again, these data suggest that relatively short vegetation is preferred by nesting curlews.

Finally, more must be learned about the impact of nest predators on curlew populations in western North America. Red fox were first sighted at Great Salt Lake in the late 1960s, with fox numbers dramatically increasing during the recent Great Salt Lake flood years (1983–90; Val Bachman, Ogden Bay WMA, personal communication). Currently, red fox are commonly sighted on the eastern shores of Great Salt Lake (personal observation), whereas during 3 years of fieldwork on the eastern shores of the lake, we sighted only one coyote (*Canus latrans*) on one occasion. Interestingly, one area at Great Salt Lake where Long-billed Curlews are still relatively common, Antelope Island, also has coyotes. The interaction between coyotes and red fox requires further study. Impacts of nest predators on Long-billed Curlew populations could be devastating because Long-billed Curlews apparently do not re-nest after their eggs are depredated (Redmond and Jenni 1986). Therefore, additional work may be required of wildlife management to minimize depredation rates and thus maintain curlew populations in certain parts of their range.

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